MONTE CARLO SIMULATION OF NEUTRON RADIOGRAPHY 2 (NUR-2) SYSTEM AT TRIGA MARK II RESEARCH REACTOR OF MALAYSIAN NUCLEAR AGENCY

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To my wonderful family, thanks for the prayers and support

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ABSTRACT

The imaging properties namely the edge spread function (ESF) and line spread function (LSF) of the Neutron Radiography 2 (NUR-2) system at Triga Mark II Reactor at Malaysian Nuclear Agency were investigated via simulation and experiment. The simulation of radiographic image was performed by using the Monte Carlo N-Particle codes version 5 and the real neutron radiographic images were collected from experiment done at NUR-2 facility. The simulation used Flux Image Radiograph (FIR) tally while for the experiment the direct method using film was used to detect the transported neutrons. The ESF of the system was measured using cadmium foil with thickness of 1 mm, 2 mm and 3 mm which blocked half of the neutron beam. Demineralized water was used as a scattering material to study the neutron scattering effect inside the material where it was placed between the cadmium foil and the detector. The differentiation of the ESF gave the LSF of the system and the full width at half maximum (FWHM) was estimated. From fast Fourier transformation of the LSF, the modulation transfer function (MTF) of the system was obtained. The results showed that the simulated neutron patterns without scattering material were similar to those found in experiment but with the presence of scattering material, the simulation and experimental data showed great differences. Cadmium with thickness of 1 mm gave the best spatial frequency response followed by 2 mm and 3 mm thick of cadmium. The range of spatial frequency for MTF at 20% was 1.0 to 2.5 cycle/mm, while the range of FWHM was 0.3 to 0.5 mm. The FWHM and MTF obtained in this study are valuable for the characterization of imaging properties of the neutron radiography system.

ABSTRAK

Sifat-sifat pengimejan iaitu fungsi taburan pinggiran (ESF) dan fungsi taburan garis (LSF) bagi sistem radiografi neutron di Reaktor Triga Mark II di Agensi Nuklear Malaysia telah dikaji menerusi simulasi dan eksperimen. Simulasi imej radiografi dilakukan dengan menggunakan perisian 'Monte Carlo N-Particle' versi 5 dan imej sebenar radiografi neutron telah diperolehi daripada eksperimen yang dijalankan di kemudahan NUR-2. Simulasi menggunakan gundalan fluks imej radiografi (FIR) manakala bagi eksperimen kaedah terus menggunakan filem digunakan untuk mengesan neutron yang dipindahkan. ESF sistem diukur menggunakan kepingan kadmium dengan ketebalan 1 mm, 2 mm dan 3 mm yang menutup separuh daripada alur neutron. Air ternyahmineral digunakan sebagai bahan penyerak untuk mengkaji kesan serakan neutron di dalam bahan di mana ia diletakkan di antara kepingan kadmium dan pengesan. Pembezaan ESF terhadap jarak memberikan LSF sistem tersebut dan lebar penuh pada separuh maksimm (FWHM) dianggarkan. Dengan mengambil jelmaan Fourier bagi LSF, fungsi pemindahan modulasi (MTF) sistem tersebut telah diperolehi. Keputusan menunjukkan bahawa corak simulasi neutron tanpa bahan penyerak adalah hampir sama seperti yang diperolehi daripada eksperimen tetapi dengan kehadiran bahan penyerak, data simulasi dan eksperimen menunjukkan perbezaan yang besar. Kadmium dengan ketebalan 1 mm memberikan sambutan frekuensi ruang yang terbaik diikuti oleh kadmium dengan ketebalan 2 mm dan 3 mm. Julat frekuensi ruang untuk MTF 20% ialah 1.0 hingga 2.5 kitar/mm sementara julat FWHM ialah 0.3 hingga 0.5 mm. MTF dan FWHM yang diperolehi dalam kajian ini adalah berharga untuk pencirian sifat pengimejan sistem radiografi neutron.